Anti-blackout system for grid connected solar installations (Solsafe concept)

General description

The Solsafe concept is a system which will automatically switch from a solar inverter connected to the public grid to a backup grid.

The installation of the Solsafe concept in a grid connected solar system enables to secure totally or partially the power supply in case of a power cut and allows the use of solar power when the grid is off.

Features & advantages

- Backup system for grid connected solar installation.
- Grid feeding with solar inverter.
- Hassle free cabling, quick installation and easy commissioning with the Solsafe S-Box.

Minimal configuration

- Range of inverters
  - **Compact Series :**
    - **All XPC serie**
    - **All C serie**
    - **All HPC serie**
  - **Xtender Series :**
    - **All XTH serie**
    - **All XTM serie**
- RCC02 / 03 (Only for Xtender series)
  - Software vers. : **1.3.8 and higher**
  - RCC User level : **Expert**

Application Schematic

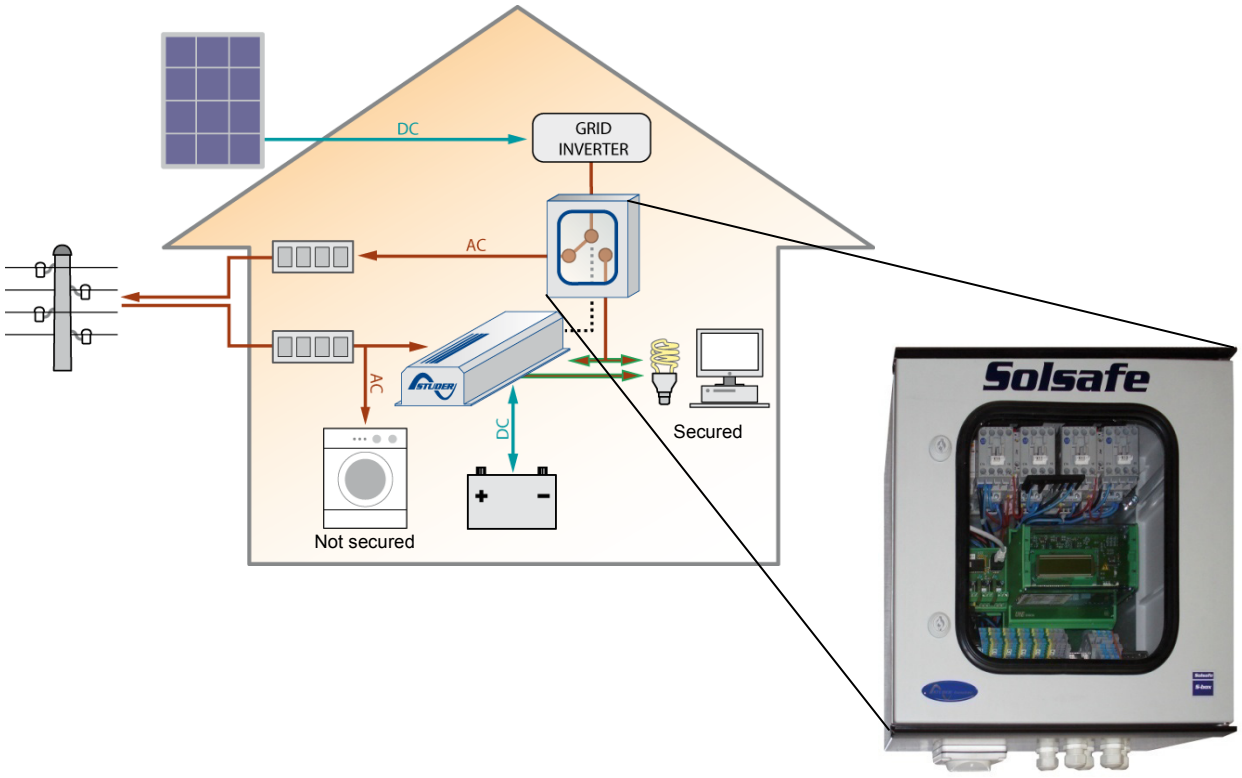


Figure 1, Solsafe concept with the Solsafe S-Box

Detailed description

The Solsafe concept

The Solsafe concept is a backup system for grid connected solar installations.

This solution enables to secure totally or partially the power supply in case of a power cut, and to keep on using the solar energy being produced.

Note that all inverter-chargers of Studer Innotec are bi-directional. This allows integrating any of them into the Solsafe concept.

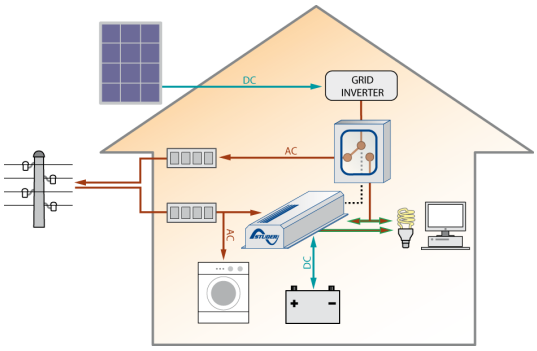


Figure 2, Solsafe concept

Compared to other similar solutions, the Solsafe concept offers the following advantages :

- It allows a great flexibility by choosing independently the grid-feeding power (matching the solar generator) and the stand-alone power (matching the peak consumption of the user).
- The grid-feeding inverter can be chosen with high voltage input range (lowering wiring costs).
- The wiring can be optimized by placing the grid-feeding inverter near the solar field
- It allows a possible upgrade of existing grid-connected installations.
- The inverter-charger allows a fast charging from the grid (important in case of frequent power cuts hindering a complete charge of the battery).
- The power available in case of islanding is added (inverter-charger Pnom + grid-feeding instantaneous power).
- Its allows an upgrade of existing stand-alone installations that are connected to the grid afterwards (adding value to the investment)
- It standardizes the amount of products to maintain and makes the staff training easier (this concept can be implemented with all our combis, XTH, XTM, XPC, Compact and HPC).
- It allows to work with standard grid-feeding inverters (SolarMax, Fronius, …) and therefore gives access to better prices.
- It ensures that no grid-feeding from the battery is possible, which actually a big concern for utilities is paying back each solar kWh supplied to the grid. Concretely it avoids that kWh's paid at a low price from the grid, then stored in the battery, are then supplied and sold at a high price from the battery to the utility grid.

The Solsafe system can be fully wired by the installer. In that case, Studer is only supplying the inverter-charger (Xtender or Compact series) and the ARM-01 Module (for Compact series) or the preset Solsafe (for Xtender series).

The wiring schematics for the Solsafe system and Solsafe three phase system are at disposal in the appendices (available at the end of this document).

Solsafe S-Box

For the Solsafe system a genuine cabling solution exists, the S-Box.

Figure 3, S-Box

The S-Box offers :

- Hassle free cabling
- Quick installation
- Easy commissioning

The S-Box can be supplied in 4 versions :

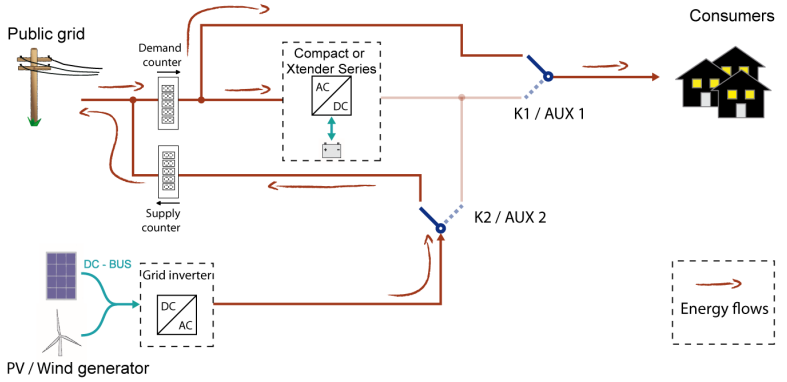
- S-Box 25A for Compact Series (S-Box-25C)
- S-Box 25A for Xtender Series (S-Box-25X)
- S-Box 25A with ENS Module for Compact Series (S-Box-25C-E)
- S-Box 25A with ENS Module for Xtender Series (S-Box-25X-E)

Solsafe concept situations

The Solsafe concept can be described by these four different situations[i]

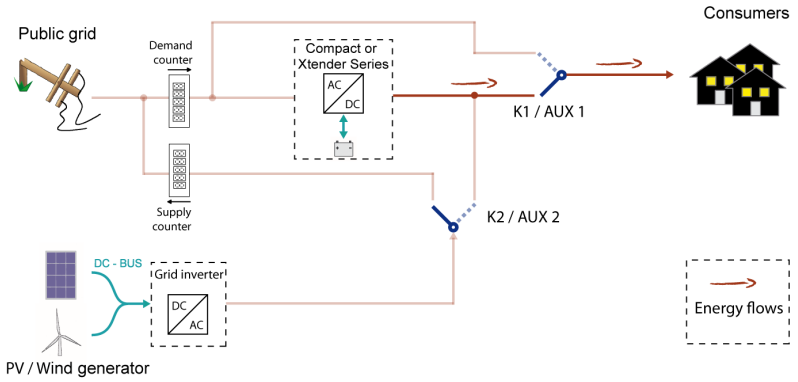
The grid is present

- K1 / AUX1 is in “bypass mode”.
- K2 / AUX2 is switched on the grid (feeding grid).
- The grid charges the batteries.



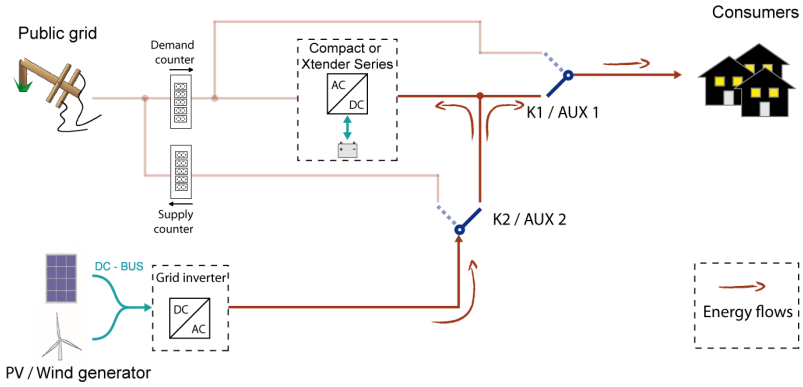
No grid and batteries fully charged

- K1 / AUX1 is in “power cut mode”: the backup inverter supplies the consumers from the batteries.
- K2 / AUX2 is switched on the grid. Solar energy is not necessary as long as the battery is “full”.



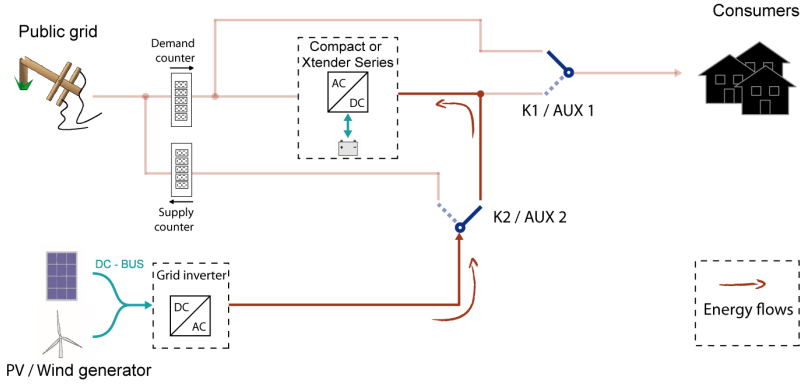
No grid and batteries partly charged

- K1 / AUX1 is in “power cut mode”: the consumers are supplied by backup inverter (batteries) and / or solar energy.
- K2 / AUX2 is switched on the backup grid. Solar energy is used for supplying the consumers and/or the batteries.(Bi-directional output of inverters)



No grid and batteries discharged

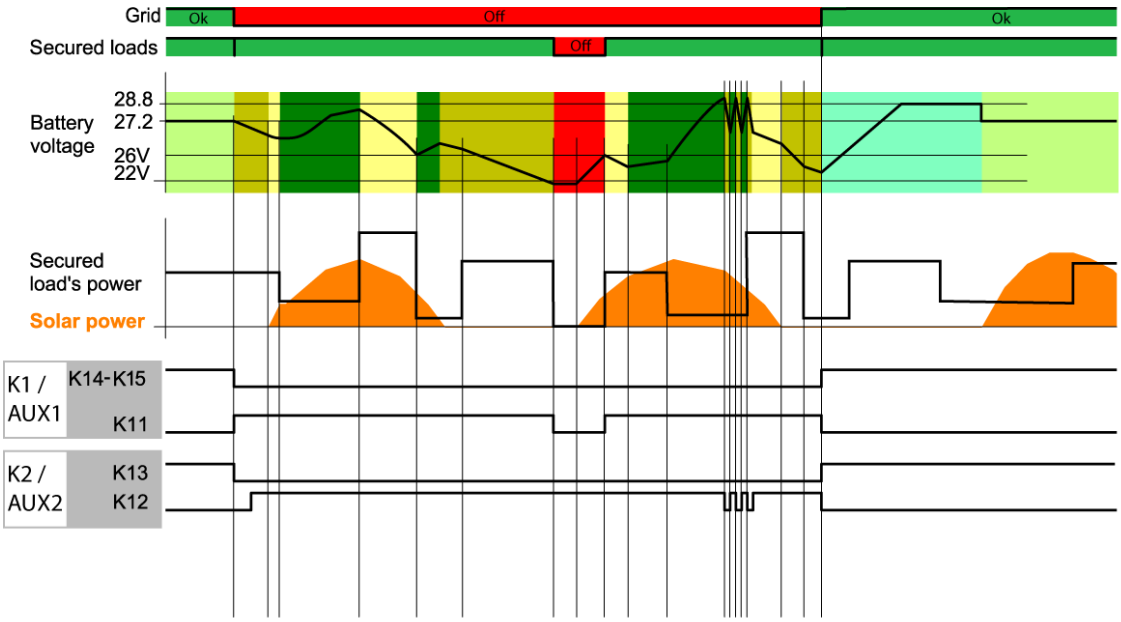
- K1 / AUX1 is in “bypass mode” and disconnects completely the consumers. It will switch back in “power cut mode” when the battery will recover a partial charged level.
- K2 / AUX2 is switched on the backup grid. Solar energy is used for charging the battery.



[i] K1, 2 are for Compact series and AUX1, 2 are for Xtender Series

Solsafe system behavior example

The graph below shows in detail the behavior of the Solsafe system in every possible case



Grid is present and battery is maintained (floating) by the grid. All the solar production is sold to the grid.

Grid is discontinued and secured loads are supplied by the Studer inverter only, as long as grid inverter is not charging (night time) or if the battery is already fully charged.

Grid is discontinued and secured loads are supplied by the Studer inverter and grid inverter. Solar power is not enough to supply loads and charge the battery.

Grid is discontinued and secured loads are supplied by the grid inverter, and excess of production is charging the battery.

Grid is discontinued and secured loads are not supplied because battery is almost fully discharged due to an average consumption greater than solar average production. The system is may be under-dimensioned or the battery capacity is diminished due to aging.
Loads will stay disconnected until battery has recovered 25% capacity.

Grid is back again and the charge of the battery is done from the grid thrugh the Compact charger with a normal cycle (bulk charge - absorbtion and floating).

Solsafe relays descriptions :

- K1 / AUX1 is always actuated until warning for LVD, and actuated again when battery level is 50% (LED 17)
- K2 / AUX2 is actuated when the unit is in inverter mode (no AC in) with a battery voltage which is less than the absorption voltage and the temperature less than 65°C
- K14 is closed when the grid is present or when K11 is open.
- K15 force K14 when grid is present
- K12 and K13 are mechanically and electrically interlocked
- K11and K14 are mechanically and electrically interlocked

Solsafe concept, installation design and commissioning

General information for Solsafe concept with Compact series

This particular application requires a Compact (XPC, C or HPC) driving the external auxiliary relay module ARM-01

The ARM-01 is a module consisting of 4 auxiliary relays to use only with the Compact series. The K1 and K2 relays have a dedicated function to the Solsafe application. The K3 relay is not used and the K4 relay is a replication of the auxiliary contact of the inverter-charger and can be programmed for particular applications

This module is already included in the S-Box (type S-Box-25C).

Using the S-Box (type S-Box-25C) will greatly facilitate the wiring of Solsafe system.

General information for Solsafe concept with Xtender series

This particular application requires an Xtender (XTH or XTM) with auxiliary contact AUX1 and AUX2 specifically programmed to drive the contactor of the source switch-over.

The specific programming is done by downloading the preset Solsafe delivered with the S-Box. If the wiring is done by the installer without the S-Box, the preset can be requested via e-mail on info@studer-innotec.com. (Specific programming description on appendices).

Using the S-Box (type S-Box-25X) will greatly facilitate the wiring of Solsafe system.

General information for the Solsafe concept with Xtender three-phase system

This particular application requires 3 Xtender (XTH or XTM) with auxiliary contact AUX1 and AUX2 specifically programmed to drive the contactor of the source switch-over.

Note that Studer Innotec does not supply pre-wired S-Box for three-phase systems. It is possible to order all the necessary equipment at Studer Innotec (List of equipment, preset Solsafe and information on the assembly are available in appendices).

ENS module

When using the Solsafe concept, the function "impedance jumps" (or ENS[i]) on the grid inverter must be always turned off (impedance of inverter is not similar to the one of the grid)[ii].

Thus, if the function "jumps impedance" is mandatory, it is required to add an external ENS module in the greed feeding path.

Studer Innotec recommends two ENS modules of the company UfE GmbH. The module ENS 26 for single phase application and the module ENS 31 for three phase application.

The module ENS 26 is already included in the S-Box type (S-Box-25C-E) and (S-Box-25X-E).

System dimensioning

PV array

The voltage of the PV generator is only given by the grid inverter whatever is the battery voltage of the inverter-charger. It must be according to grid inverter.

Grid Inverter

The power of the grid inverter can be freely chosen but the maximum output power should not be higher than the inverter-charger nominal power.

Wiring should be in accordance with the manufacturer's prescriptions.

Battery

Battery should be sized according to the backup time requirement, but we recommend a min. size of : C10 ≥ 5x P_{pv}/U_{batt}.

Inverter-charger (Compact series or Xtender series)

The inverter-charger must be sized according to the maximum secured power.

⚠	For the Compact and Xtender series, the stand-by must be at 0 to work with the Solsafe system.

Notes

[i] An ENS-Module is used to connect decentralized electricity generators to the public electricity supply and in the event of faults in the mains supply, the ENS-Module interrupts the feeding of electricity of the monitored phase into the mains to prevent an islanding effect.
The following deviations are monitored :

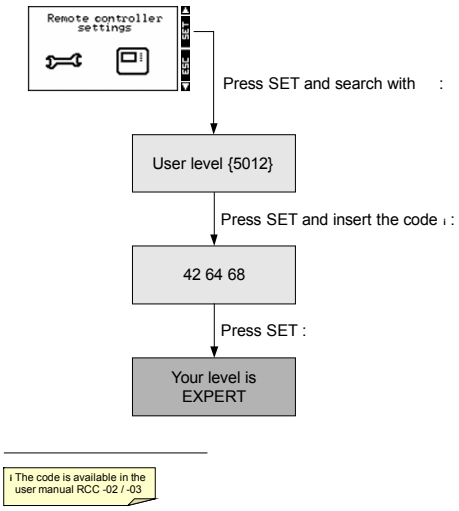
- overvoltage and undervoltage
- frequency deviation
- impedance jumps

These instructions are directly extracted from Chapter 2.1 of Module ENS manual of the company UfE GmbH. More information available on www.ufegmbh.de

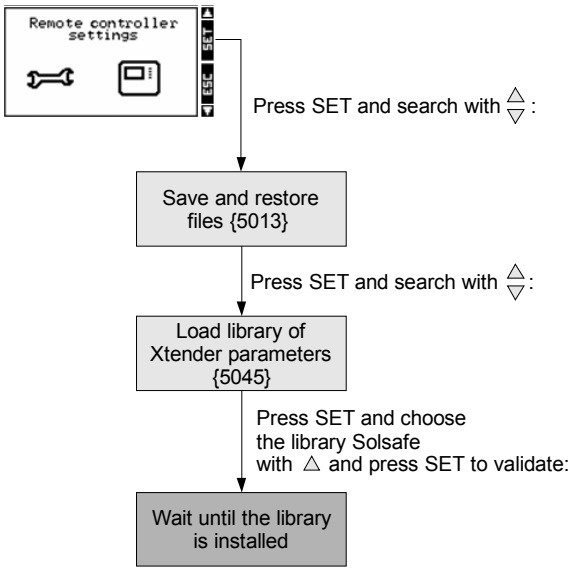
[ii] Grid inverter manufacturer will give the procedure to deactivate the function "impedance jumps".

RCC -02 / -03 programming guide[i]

Go to Expert level


Remote controller settings
Press SET and search with :
User level {5012}
Press SET and insert the code i :
42 64 68
Press SET :
Your level is EXPERT
i The code is available in the user manual RCC -02 / -03

Load preset “Solsafe” [ii]


Remote controller settings
Press SET and search with △▽ :
Save and restore files {5013}
Press SET and search with △▽ :
Load library of Xtender parameters {5045}
Press SET and choose the library Solsafe with △ and press SET to validate:
Wait until the library is installed

Notes

[i] (Only for Solsafe concept with Xtender series and Solsafe concept with Xtender three phase system).

[ii] Preset “Solsafe” description available in the appendices.

Notes

Worldwide sales and service

Switzerland

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1950 SION / Switzerland
Tel :027 205 60 80 / Fax : 027 205 60 88
Email: info@studer-innotec.com
Web : http://www.studer-innotec.com

Limitation of responsibility

The use of STUDER INNOTEC devices is the responsibility of the customer in all cases. STUDER INNOTEC reserves the right to make any modification to the product without prior notification.

Appendices

- Appendix 1, S-Box scheme (Power)

- Appendix 2, S-Box scheme (Control)

- Appendix 3, Scheme Compact series and S-Box-25C(-E)

- Appendix 4, Scheme Xtender series and S-Box-25X(-E)

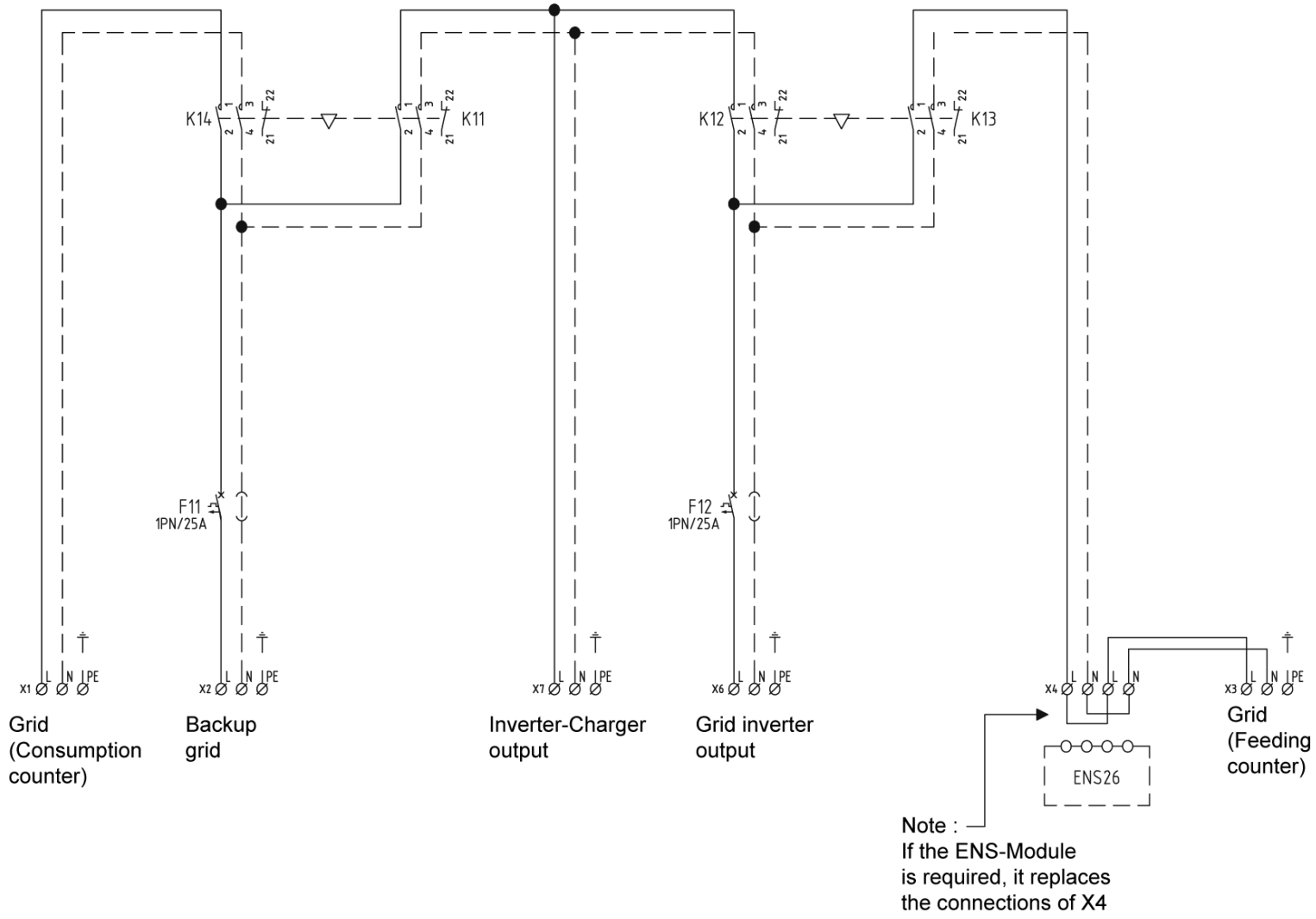
- Appendix 5, Scheme Xtender three-phase system

    - Appendix 5.1, List of parts

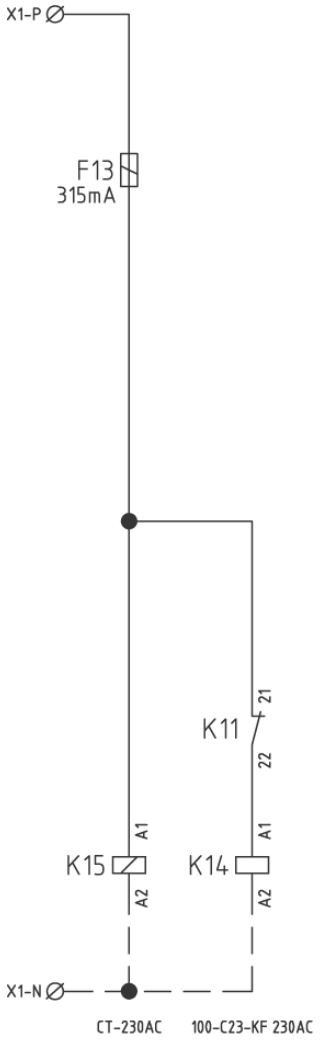
    - Appendix 5.2, Example of wiring

    - Appendix 5.3, Description of the preset Solsafe

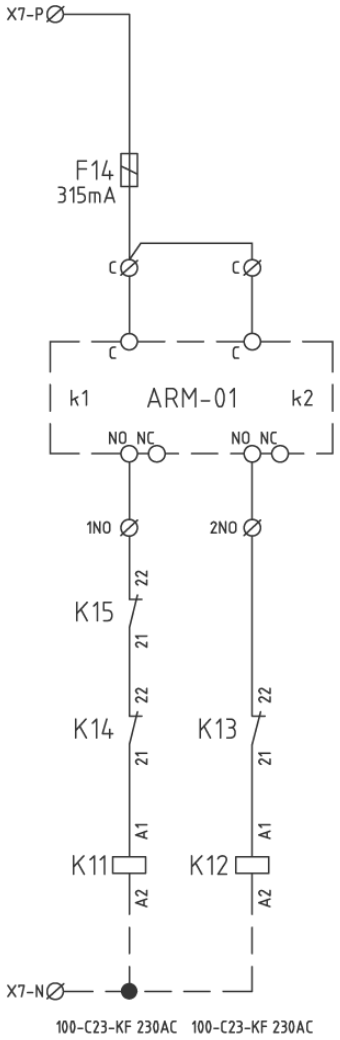
Appendix 1, S-Box scheme (Power)



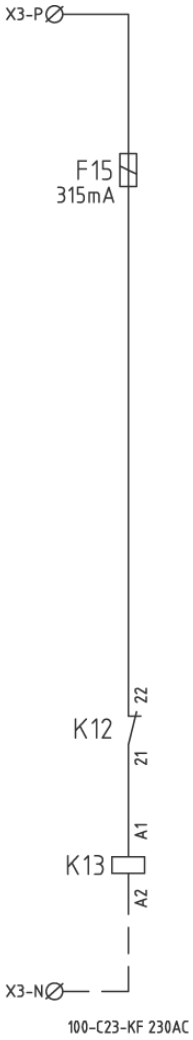
Appendix 2, S-Box scheme (Control)



Grid
(Consumption
counter)

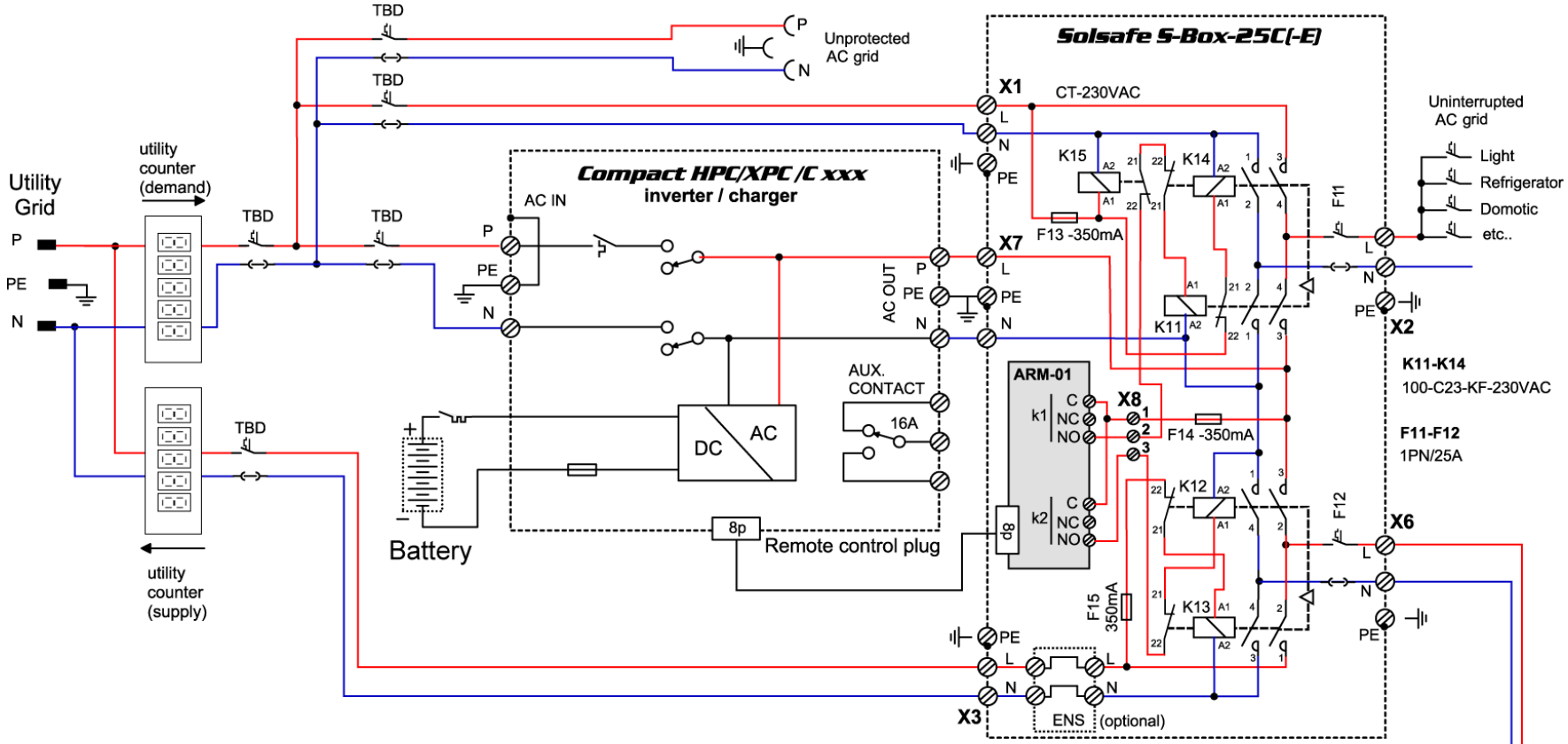


Inverter-Charger
output



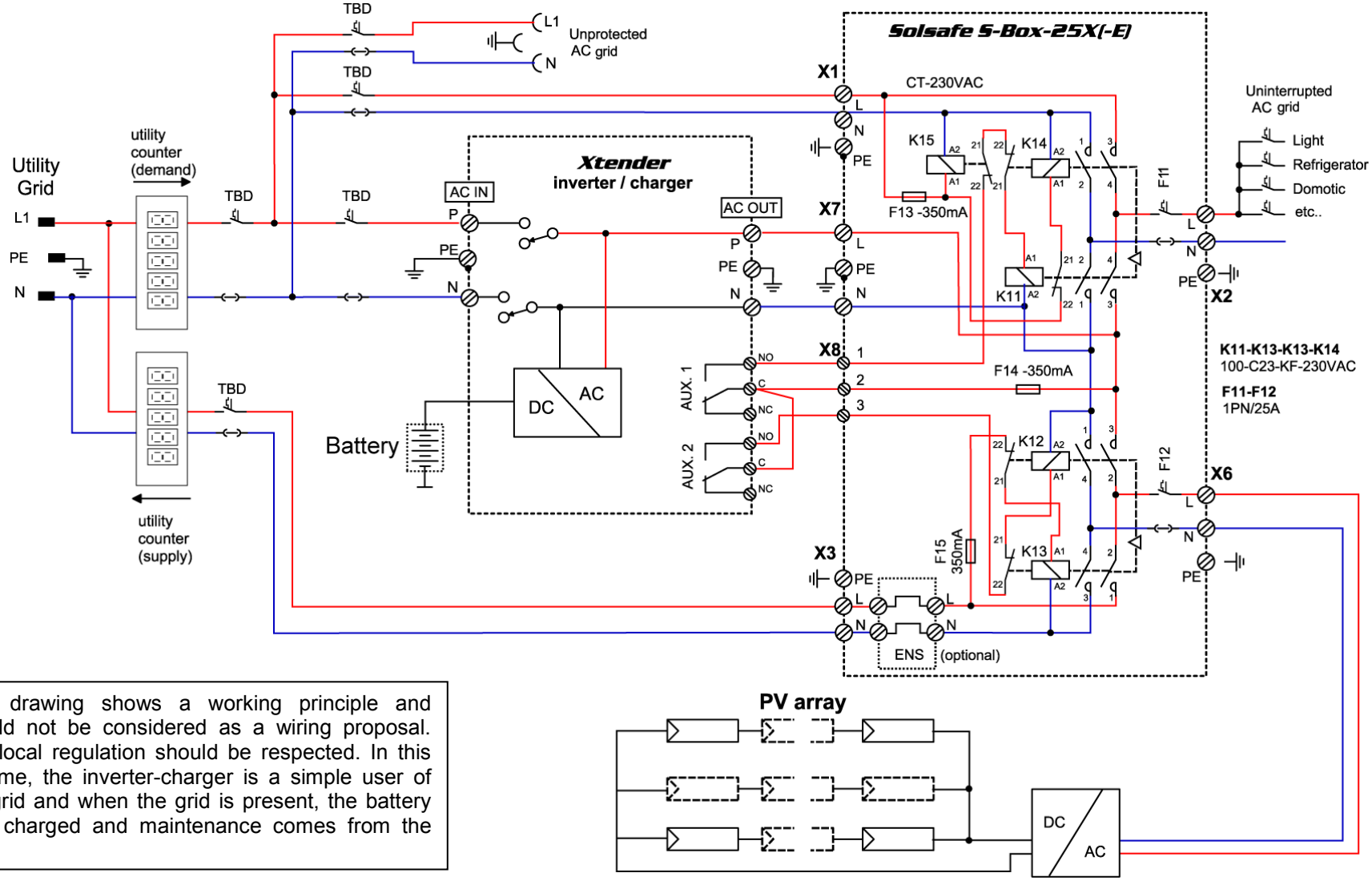
Grid
(Feeding
counter)

Appendix 3, Scheme Compact series and S-Box-25C(-E)



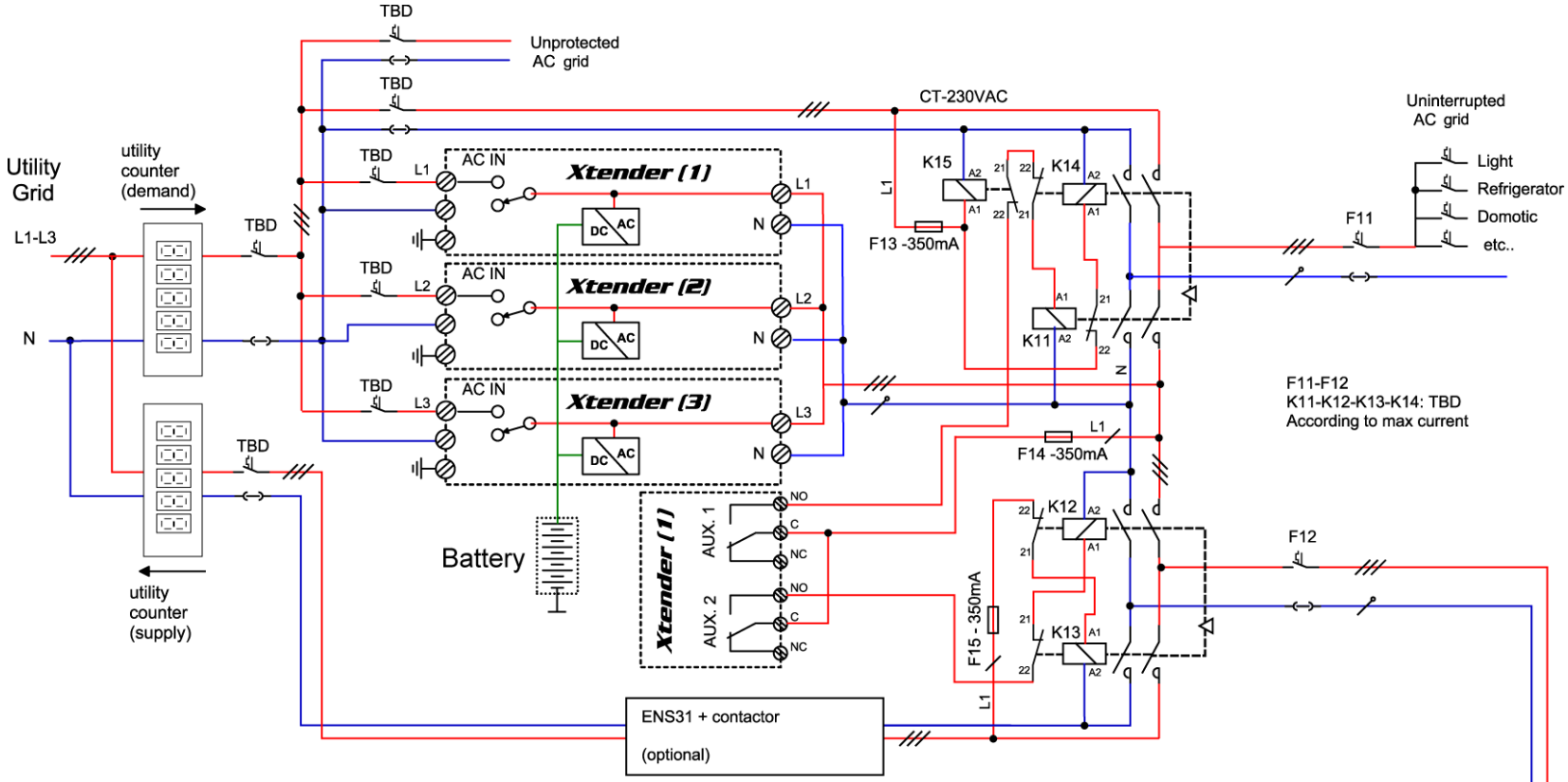
This drawing shows a working principle and should not be considered as a wiring proposal. The local regulation should be respected. In this scheme, the inverter-charger is a simple user of the grid and when the grid is present, the battery gets charged and maintenance comes from the grid.

Appendix 4, Scheme Xtender series and S-Box-25X(-E)



This drawing shows a working principle and should not be considered as a wiring proposal. The local regulation should be respected. In this scheme, the inverter-charger is a simple user of the grid and when the grid is present, the battery gets charged and maintenance comes from the grid.

Appendix 5, Scheme Xtender three-phase system



This drawing shows a working principle and should not be considered as a wiring proposal. The local regulation should be respected. In this scheme, the inverter-charger is a simple user of the grid and when the grid is present, the battery gets charged and maintenance comes from the grid.

Appendix 5.1, List of parts

The various components listed below are available in kit form at Studer Innotec.

Single-phase Solsafe Kit with Compact series

Designation	Studer reference	Quantity
Single-phase breaker [25A]	DISJ-MG-MONO-25A-C	2
Installation relay [16A]	REL-INSTAL-16A	1
Contactor three-phase [Allen-Bradley 23A]	REL-CONTACTEUR-3L-23A-230V	4
Mechanical lock block for contactor	REL-CONTACTEUR-BLOC-VERROU	2
Junction block [Woertz – 6mm^2 – Grey]	B-WOERTZ-6#-GRIS	9
Junction block [Woertz – 6mm^2 – Blue]	B-WOERTZ-6#-BLEU	5
Junction block [Woertz – 6mm^2 – Yellow/Green]	B-WOERTZ-6#-JAUNE-VERT	5
Closure for junction block [Woertz]	B-WOERTZ-PAROI-DE-FERMETURE	2
Fuse block [Woertz – 4mm^2 – Grey]	B-WOERTZ-4#-FUSIBLE	3
Locking block [6/6 – Grey]	B-BUTEE-PLASTIQUE	2
ARM-01 module	ARM-01	1
Optional		
ENS26 [UFEgmbh]	ENS26	1
Fuse block [Woertz – 4mm^2 – Grey]	B-WOERTZ-4#-FUSIBLE	1

Single-phase Solsafe Kit with Xtender series

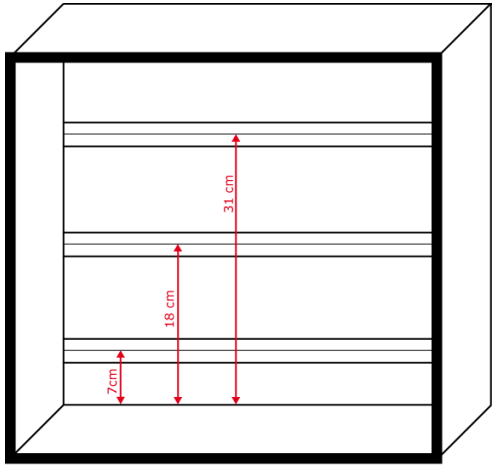
Designation	Studer reference	Quantity
Single-phase breaker [25A]	DISJ-MG-MONO-25A-C	2
Installation relay [16A]	REL-INSTAL-16A	1
Contactor three-phase [Allen-Bradley 23A]	REL-CONTACTEUR-3L-23A-230V	4
Mechanical lock block	REL-CONTACTEUR-BLOC-VERROU	2
Junction block [Woertz – 6mm^2 – Grey]	B-WOERTZ-6#-GRIS	9
Junction block [Woertz – 6mm^2 – Blue]	B-WOERTZ-6#-BLEU	5
Junction block [Woertz – 6mm^2 – Yellow/Green]	B-WOERTZ-6#-JAUNE-VERT	5
Closure for junction block [Woertz]	B-WOERTZ-PAROI-DE-FERMETURE	2
Fuse block [Woertz – 4mm^2 – Grey]	B-WOERTZ-4#-FUSIBLE	3
Locking block [6/6 – Grey]	B-BUTEE-PLASTIQUE	2
SD card with Solsafe preset	SD-CARD-SOLSAFE	1
Optional		
ENS26 [UFEgmbh]	ENS26	1
Fuse block [Woertz – 4mm^2 – Grey]	B-WOERTZ-4#-FUSIBLE	1

Three-phase Solsafe Kit with Xtender series

Designation	Studer reference	Quantity
Three-phase breaker [25A]	DISJ-MG-TRI-25A-C	2
Installation relay [16A]	REL-INSTAL-16A	1
Contactor three-phase [Allen-Bradley 23A]	REL-CONTACTEUR-3L-23A-230V	4
Mechanical lock block	REL-CONTACTEUR-BLOC-VERROU	2
Junction block [Woertz – 6mm^2 – Grey]	B-WOERTZ-6#-GRIS	19
Junction block [Woertz – 6mm^2 – Blue]	B-WOERTZ-6#-BLEU	5
Junction block [Woertz – 6mm^2 – Yellow/Green]	B-WOERTZ-6#-JAUNE-VERT	5
Closure for junction block [Woertz]	B-WOERTZ-PAROI-DE-FERMETURE	2
Fuse block [Woertz – 4mm^2 – Grey]	B-WOERTZ-4#-FUSIBLE	3
Locking block [6/6 – Grey]	B-BUTEE-PLASTIQUE	2
SD card with Solsafe preset	SD-CARD-SOLSAFE	1
Optional		
ENS31 [UFEgmbh]	ENS31	1
Fuse block [Woertz – 4mm^2 – Grey]	B-WOERTZ-4#-FUSIBLE	3

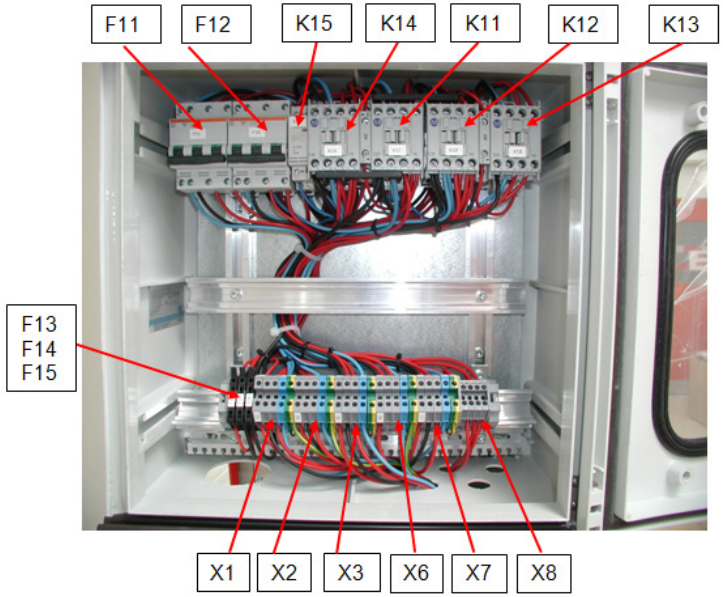
Appendix 5.2, Example of wiring

The box



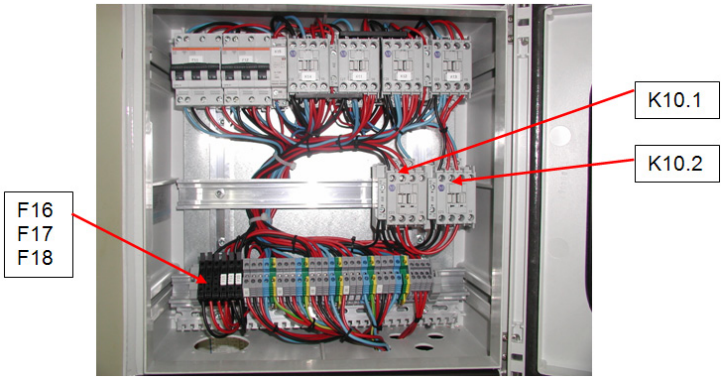
Box type 1448-500
(400 X 400 X 200)
www.rittal.ch

The assembling

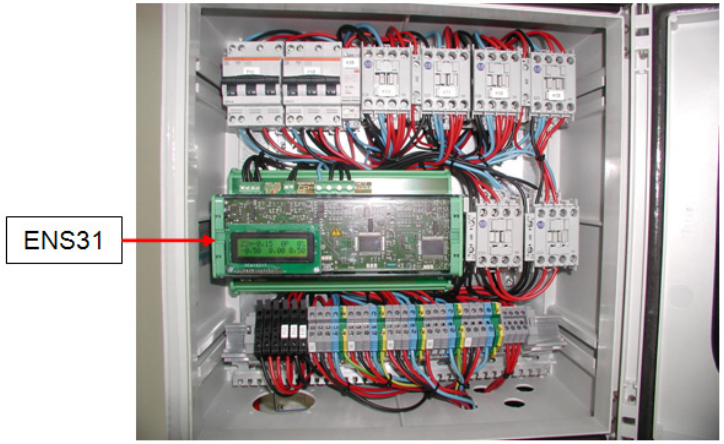


⚠	The distances between the bars of support must be respected so all components of the system can fit in the box.
	This system can be connected in any electrical box whose size permits it.
	The wiring must be according to the local regulation
	The bars of support are not provided by Rittal.

⚠	At the top of the box are wired : Relays K15, K14, K11, K12 and K13 and fuse holders F11 and F12.
	At the bottom of the box are wired : Fuse holders F13, F14 and F15 and the terminals X1, X2, X3, X6, X7 and X8
	The cables must be wired as close as possible to relays and contacts to leave a place for the ENS 31



⚠	Here are added onto the middle bar the ENS31 relay's K10.1 and K10.2 and on the bottom bar the ENS31 fuse holder's F16, F17 and F18.
	It makes sense to put ENS31 before placing K10.1 and K10.2 to adjust the height of the central bar. Then, remove the ENS31 to facilitate wiring K10.1 and K10.2 and remplace it.



⚠	Finally, connect the ENS31 with particular attention to the order of phases
	Note that the neutral must be connected to the ENS31 otherwise the unit may be damaged. (All references for the ENS31 are in its user manual.)

Appendix 5.3, Description of the preset "Solsafe" for Xtender series

If it is not possible to obtain the preset "Solsafe", it is possible to set by yourself the RCC -02 / -03 using the parameter description below.

Applicable from software version 0.1.3.8 | **XTH/M 12 – 24 – 48 VDc**

Menu Combi Inverter-Charger

Param 1438: Solsafe system presence | ***Yes***

Menu Inverter

Param 1187: Stand-by level | ***0***

Menu RELAIS 1

Load shedding when the battery is almost empty and load reconnected when battery back to 2,25V/cell. By default: load shedding means Aux. relay activated when battery ok.

Param 1202: Operating mode (AUX 1) | ***Value: reversed automatic***
Param 1497: Combination of the events the auxiliary contact 1 | ***Value: Any (Function OR)***

Menu 1245: Active in function of the battery voltage (AUX 1)

Param 1288: Use of dynamic compensation of battery level (AUX 1) | ***Yes***
Param 1246: Battery voltage 1 activate (AUX 1) | ***Yes***
Param 1247: Battery voltage 1 (AUX 1) | **11.6 – *23.2 – 46.4 [VDc]***
Param 1248: Delay 1 | ***1min***
Param 1249: Battery voltage 2 activate (AUX 1) | ***Yes***
Param 1250: Battery voltage 2 (AUX 1) | **12 – *24 – 48 [VDc]***
Param 1251: Delay 2 | ***10min***
Param 1252: Battery voltage 3 activate (AUX 1) | ***Yes***
Param 1253: Battery voltage 3 (AUX 1) | **12.2 – *24.3 – 48.6 [VDc]***
Param 1254: Delay 3 | ***30min***
Param 1255: Battery voltage level to deactivate (AUX 1) | **13.5 – *27V – 54 [VDc]***
Param 1256: Delay to deactivate (AUX 1) | ***60min***

Warning: None of the other parameters present in relay AUX1 menu should be changed!

Menu RELAIS 2

Condition to have the grid inverter re-directed at the output of the Xtender. By default: disconnected

Param 1311: Operating mode (AUX 2) | ***Value: automatic***
Param 1498: Combination of the events the auxiliary contact 2 | ***Value: All (Function AND)***

Menu 1456: Contact active on event, only theses parameters:

Param 1340: Inverter active | ***Yes***
Param 1519: Xtender ON (AUX 2) | ***Yes***
Param 1521: No over-temperature, no overload, no transformer over temperature

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Menu 1353: Active in function of the of battery voltage (AUX 2)

Param 1354: Use of dynamic compensation of battery level (AUX 2) | ***Yes***
Param 1355: Battery voltage 1 activate (AUX 2) | ***Yes***
Param 1356: Battery voltage 1 (AUX 2) | **13 – *26V – 52 [VDc]***
Param 1357: Delay 1 | ***5min***
Param 1364: Battery voltage level to deactivate (AUX 2) | **14 – *28V – 56 [VDc]***
Param 1356: Delay to deactivate (AUX 2) | ***0min***

Warning: None of the other parameters present in relay AUX2 menu should be changed!